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Five Factors in Heating Costs

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Written in the interests of better and more economical heating in large industrial plants

GRINNELL COMPANY

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F. H. MAYNARD, PRESIDENT,
1 Liberty Street, New York.

RUSSELL GRINNELL, VICE-PRESIDENT AND GENERAL MANAGER,
260 West Exchange Street, Providence, R. I.

W. A. NERACHER, 2D VICE-PRESIDENT,
Warren, Ohio.

H. B. CROSS, SECRETARY,
260 West Exchange Street, Providence, R. I.

L. W. JONES, TREASURER,
260 West Exchange Street, Providence, R. I.

ALFRED FRITZSCHE, GENERAL SALES MANAGER,
Society for Savings Building, Cleveland, O.

Heating and Power Piping Department

HAROLD S. HALL, Sales Manager,
Cleveland, Ohio, Society for Savings Building.

A. W. MOULDER, Chief Engineer,
Warren, Ohio.

EASTERN DEPARTMENT

J. C. HARTWELL, Department Manager,
RALPH FIELD, Chief Engineer,
Providence, R. I., 260 West Exchange Street.

WESTERN DEPARTMENT

F. M. DAUGHERTY, Department Manager,
Cleveland, Ohio.

A. W. MOULDER, Chief Engineer.

V. J. WILSON, Contracting Engineer,
Cleveland, Ohio.

C. E. MALLERY, Department Manager,
Cincinnati, Ohio.

SOUTHERN DEPARTMENT

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North Charlotte, N. C.

H. P. CONWAY, Department Manager,
Atlanta, Ga.

O. V. BRANSON, Chief Engineer,
Atlanta, Ga.

GAS HEATING DEPARTMENT

GEORGE S. BARROWS, Manager,
Providence, R. I., 260 West Exchange Street.

Five Factors In Heating Costs

High Fuel Costs Demand Better Systems

When coal was $1.00 and $2.00 a ton, the selection of a heating system for an industrial plant boiled down to about this—"What's the cheapest system that will keep the plant warm?"

That day has gone. It is doubtful if it ever returns.

Today fuel costs are such that many plants are wasting thousands of dollars a year because their heating systems were chosen on the basis of first cost alone, without regard to other heating expenses.

Today fuel costs are such that the manufacturer who is building should give to the choice of a heating equipment the same painstaking attention that he gives to productive facilities.

Due to the fact that heating until recently was largely a matter of first cost, many manufacturers are unacquainted with the other factors which should receive consideration in the selection of a heating system. Some of these factors at first glance appear to have nothing to do with heating whereas in reality they are very closely related to it.

Is Your Roof a Huge Radiator?

For instance, we had a case recently where a manufacturer had decided upon a certain type of roof. In his mind a roof was a roof. It had nothing to do with heating. As a matter of fact, we were able to show that manufacturer how the excessive heat losses through the roof he had selected would cost him several thousand dollars a year in coal bills over certain other types of roof. In reality he had unwittingly made his roof a huge radiator to warm the great out-of-doors. And he was paying for the coal out of his profits!

Saving $7000 a Year In Fuel

A study of heat losses precedes the calculation of radiating surfaces in the most modern heating practice. Such a study in a theoretical one-story building 500 by 200, for example, shows that the type of roof can affect the initial cost of the heating system in such a building some $10,000 and the annual expense for fuel as much as $7,000.

There is no one system that is a cure-all for every heating problem. Sometimes steam is best. Sometimes hot water. But there are several ways of generating steam and warming water. The selection of the means for generating heat and the choice of the medium for conveying it to radiating surfaces demands engineering study of the whole problem. In some plants heating can be an almost costless by-product of power or process.

No General Rules

The many different considerations affecting each individual plant makes it exceedingly difficult to lay down general rules which can be applied universally to specific cases. As the country's largest consultant manufacturer on all that relates to industrial piping and as the oldest heating firm in America, our opinion, based upon seventy years' experience, may be of value to manufacturers considering the heating problem.

If what we have to say results only in their retaining proper engineering service to adequately and intelligently thrash out the whole proposition, we feel confident that an important forward step will have been taken in heating economy.

Factors Governing the Choice of a Heating System

Cost More Than Initial Expense

In selecting a heating system, cost, of course, is the primary consideration. But cost means a great deal more than initial investment. Cost is something not only of today but of tomorrow and ten years from tomorrow. So considered, heating cost clearly consists of these five elements:—

1. *Expense of operation*
2. *Adaptability*
3. *Maintenance expense*
4. *Depreciation*
5. *Initial investment*

Small Industrial Plants

How Factors Vary

The relative importance of these five factors varies for different plants. In a comparatively small plant, for instance, the expense of operation might well be so nominal as not to weigh against the increased first cost necessary to install a system approaching 100% efficiency. Moreover, expense of operation as a rule is possibly influenced more by proper control than by any other one factor. The relative difficulty of proper control, except where there is central control, increases as the size of the plant increases. The small plant owner, therefore, does not have to figure as closely as his larger neighbor on a means of having his heating system respond quickly to outside temperature changes.

As far as depreciation and maintenance go, these are factors applying more to types of systems than to the plants themselves. It is none the less true that here again the small plant owner is more fortunate than his larger rival in that pipe runs are short and the layout ordinarily so simple that there need be few if any underground

lines, as there often must be with certain types of systems in large plants. Underground lines usually mean not only expense in installation but in repairs.

Steam Usually Best For Small Plants

Our experience has been that a steam heating system is usually more economical and satisfactory in the small plant than any other type. This is particularly true when it is installed in conjunction with a power plant where exhaust steam is available *only a part* of the twenty-four hours. When the power conditions are such that there is an excess of exhaust steam for heating in most weather the condition is even more favorable. In such cases the plant may be allowed to cool off over night and yet on account of the abundance of exhaust steam available, it can quickly be heated in the morning without robbing the plant of its necessary productive power.

Provide For Additions

There is one word of caution which our experience prompts us to offer the smaller plant owner. It is to have his heating system so designed and installed as to easily provide for the additions which the future is so apt to bring about. Proper engineering advice should be sought before making additions of this kind, because all too often proper heating of the whole building is sacrificed by blindly adding more radiation without due attention to the necessity of increasing pipe sizes.

Large Industrial Plants

Hot Water The Ultimate System

While by far the larger part of our heating work in the past and even today, is steam, we believe the time will surely come when hot water under forced circulation will be the standard heating medium in all large industrial plants. This belief is based on a thorough consideration of the five previously mentioned factors entering into heating costs. For the large industrial plant the chief of these factors on close analysis almost invariably will prove to be "cost of operation."

A manufacturer could not give away motor trucks which burned gasoline at the rate of a gallon a mile. And yet a great many manufacturers are burning coal or oil in heating systems so ill-suited to conditions as to make a "mile to the gallon" motor truck look like the essence of conservation. Mr. Van H. Manning, former director of the United States Bureau of Mines, said in 1918: "Last year the United States mined 600,000,000 tons of coal, the greatest production ever witnessed in the world, and of this amount we WASTED 150,000,000 tons, or 25%, through inefficient use."

Cost of Operation

Operating Figures Dangerous

It is easy enough to compile theoretical figures of the cost of operating a heating plant, but our experience is that such figures are dangerous in that they cannot take care of the chief variable—the human factor. Every manufacturer knows better than anyone else just what he can count on among his own employees and, if he understands the fundamentals underlying heating costs, he can form sound conclusions as to just what those fundamentals may mean in his particular property and with his particular class of employees.

Behind everything else in heating is outside temperature. If the thermometer would go down to zero and stay there for four or five months, heating wouldn't be a science but a cinch. But the thermometer records the antics of a very erratic individual called the weather man. Consequently it bobs about much more than most people think it does.

The real job of the heating engineer is to outwit the weather man!

Outside Temperature Changes The Big Item

He outwits the weather man in direct proportion to the evenness he maintains in inside temperature, no matter what the fluctuations of the outside temperature.

The four charts on the following two pages show, in some measure, what the heating engineer is up against. These charts are taken from the 1919 report of the Committee on Heating of the Commercial Section of the American Gas Association. They show the daily temperature changes in four widely separated localities. Similar charts are available for other sections and they have a very important bearing on the choice of a heating system.

Conditions In San Francisco

These charts contain the material for quite a voluminous pamphlet. Here we only wish to point out that San Francisco manufacturers would need a very different sort of heating equipment than would your Boston business man. In San Francisco some heat is needed practically every day in the year, but only in January is it needed throughout the day. Unless exhaust steam that cannot be utilized in other ways is available, the San Francisco manufacturer would do well to heat with gas which is not only extremely easy to control, but which can be so utilized that there is no heat wasted by being held in a heating medium after the need for heat has passed. This might not be true if the heat requirements of the winter months were excessively heavy.

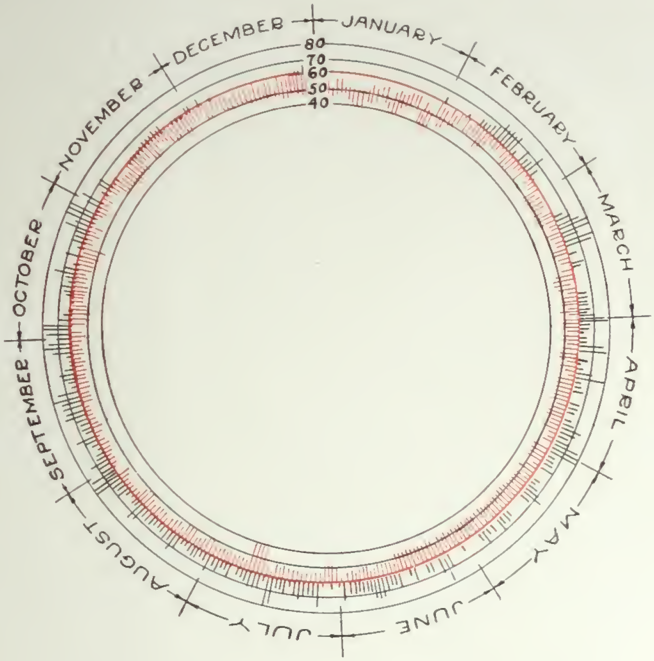


Chart showing the daily range of outside temperature in San Francisco during the heating season of 1915-16. Red lines show when heat is required.

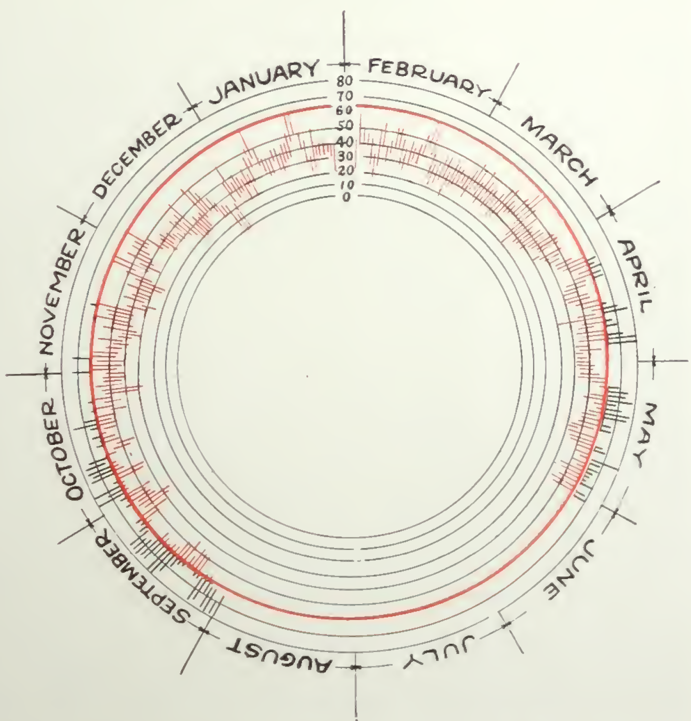


Chart showing the daily range of outside temperature in Boston, Mass. during heating season of 1914-15. Red lines show when heat is required.

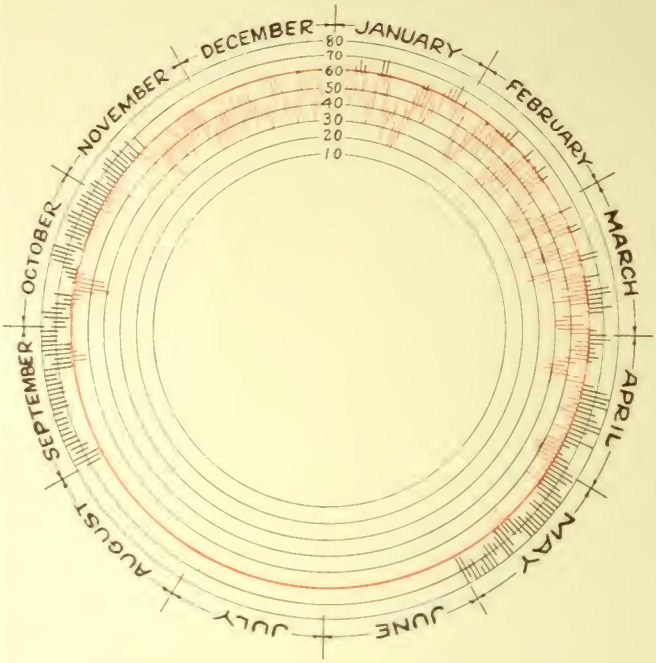


Chart showing the daily range of outside temperature in Atlanta, Ga. during the heating season of 1915-16. Red lines show when heat was required. No temperatures under 20 degrees or over 80 degrees are shown.

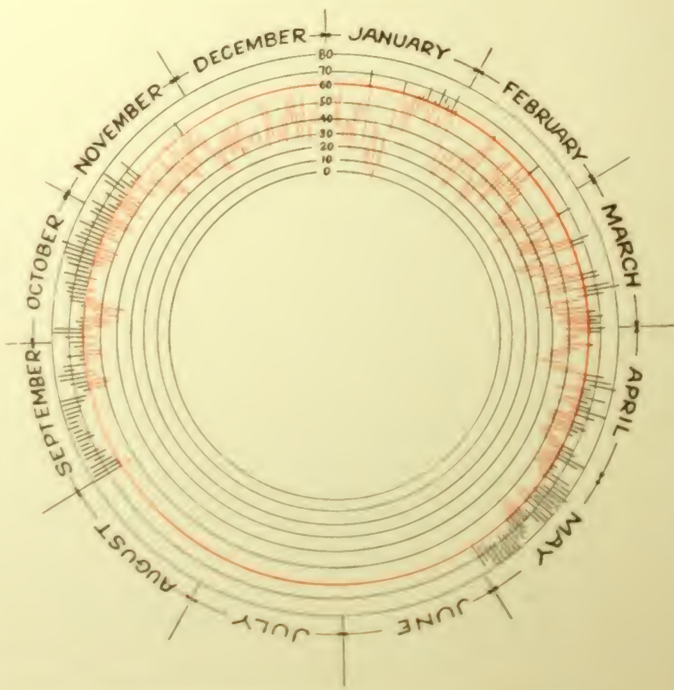


Chart showing daily range of outside temperatures in Louisville, Ky. during heating season, 1915-16. Red lines show when heat was required.

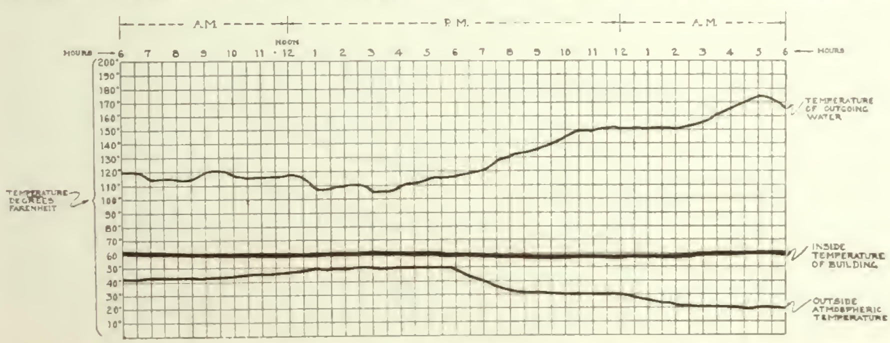
In Boston and Louisville there are many days during the heating season when heat is required only a part of the day and in the latter city numerous days when no heat whatever is required.

In both these localities the temperature changes of 24 hours are often 20 to 25 degrees. Now and then they are 40 degrees.

Demands Flexible Heating System

Such temperature fluctuations from day to day absolutely demand a flexible heating system of easy and positive control. Our reasons for believing that hot water is the ultimate heating system for large industrial plants, are that it is elastic and that it provides for one-man control of the most positive kind. We do not make this statement for all types of hot water heating systems, but do make it for the Grinnell System which is different in certain important particulars from any of which we have knowledge.

The story of how the Grinnell System outwits the weather man has been well written by the recording thermometers in the Parish and Bingham Corporation plant in Cleveland. The charts as made by those thermometers for a typical winter day are reproduced below.



Outside Temperature Change of 30 Degrees

Briefly, these charts show that with an outside temperature change of 30 degrees in twenty-four hours, the temperature inside the plant was successfully maintained within two degrees either way of the required temperature of 60 degrees. Partly this accomplishment was due to the flexibility of water as a heating medium and partly it was due to the intelligent work of the engineer in handling his heating system. Ease of control no doubt was a substantial factor in the engineer's ability to regulate his heat in conformity with rapidly changing outside temperature.

It is possible to approach these results with certain types of steam systems. But the steam system that will successfully cope with such a hot water performance as this generally equals or exceeds

it in first cost due to expensive control devices and accessories and it will far exceed it in two other factors of heating expense—depreciation and maintenance.

Usually in the large plant the only steam systems which can be considered as competitors of hot water are direct vacuum steam and blower systems, which are the steam systems we have in mind in the following discussion.

There are two factors of outstanding importance in operating expense. The first is the flexibility of the heating medium itself—i. e.—the ability to raise or lower temperature over a wide range. The second is the simplicity or ease of control.

Parish and Bingham Plant Equipped with Grinnell Hot Water Heating System Note Overhead and Side Wall Radiation

With any type of steam system 212 degrees of temperature in the heating medium is obviously the minimum. The maximum for any low pressure or vacuum steam system is 227 degrees. The extreme range therefore is only 15 degrees. Regulation of room temperature with normal outside temperature changes must therefore be by means of valves on many individual radiating surfaces or by the far more common expedient of raising and lowering windows.

One illustration is enough to show the utter waste of controlling room temperature by means of windows. When you open a window you do so because you want less heat. That should mean less coal. But when you open a window you put the radiating surface to work harder than before. You want less heat and you

burn more coal to get it! And the reason for this is that heat radiation is in a constantly increasing proportion to the difference between the surrounding temperature and the temperature of the radiating surface. For instance, an ordinary cast iron steam radiator having 100 square feet of surface in a temperature of 70 degrees would condense 25 lbs. of steam per hour. With the surrounding temperature at 30 degrees, the condensation would be 33 lbs. per hour. And this difference in condensation rate does not include any allowance for increased velocity of air passing over the radiator, which also increases the amount of condensation. For example, take your ordinary desk fan and place it in front of your radiator and blow air

Another View of Parish and Bingham Plant Note Overhead Radiation and also Treatment of Radiating Surfaces Around the Large Door at Left

(at an increased velocity) over the radiator and note how quickly the room is over-heated. How much coal, we wonder, is being burned up in American manufacturing plants each year to cool off rooms where the chief heating control device is the window?

Of course, if the control valves on individual radiators or coils are properly handled by one man whose chief duty is that work, a direct steam system, by constant closing and opening of valves, can be regulated to a certain extent in conformity with outside temperatures. But experience has proved that unless the system is thus skillfully handled, the average run of employees will adopt the quicker and more wasteful expedient of opening the windows.

Every manufacturer must decide for himself just how intelligent and painstaking will be the co-operation of his operatives in helping him maintain proper temperature and thus cut heating expense. This element in the situation varies, depending on the size of the establishment and the class of employees. As a general rule, the only regulation that can be definitely counted on is when the building is so badly overheated that the main steam valves are closed.

Cannot Count On Regulation

The blower system, from the standpoint of economical operation, is not to be compared with either the vacuum steam or hot water systems, the cost of fuel very often running from two to four times that of a hot water system, depending on the number of air changes made. Where air is re-circulated and automatic temperature regulators installed for the various control valves, it is possible with this system to equal the efficiency of a hot water system as far as uniform temperature is concerned. In this case, however, three other items of heating costs enter to destroy the equality—namely, initial expense, depreciation and maintenance. These will be considered later.

Hot Water The Most Flexible Medium

Contrasted with these operating limitations of steam systems, the hot water system is wonderfully flexible. In the first place, the heating medium itself can be varied through a wide range of temperatures from say 80 degrees to 220 degrees. And at any of those temperatures, it is still a heating medium, radiating warmth, whereas with steam, there must be 212 degrees to get any warmth whatever from the radiating surfaces. Refer back to the charts on Page 9. You will see that when the outside temperature was 50, the temperature of the outgoing water was 115 degrees. And when the outside temperature was 20 degrees, the water temperature was 160 degrees. The greater flexibility of water as a medium for conveying heat is, in fact, quite obvious.

But the flexibility of hot water as a heating medium loses a considerable part of its value unless the whole equipment is properly designed so that there is uniform and efficient circulation throughout all parts of the system without the introduction of throttling valves.

Importance of Frictional Resistance

This is where the Grinnell Hot Water Heating System is superior. It is so carefully designed as to frictional resistances, pipe sizes, etc. that there is no necessity for such throttling valves anywhere in the system.

In this system not only is the introduction of throttling valves not necessary to the proper operation of the system, but moreover the uniform distribution of water, which is another way of saying temperature, is absolutely guaranteed by this Company.

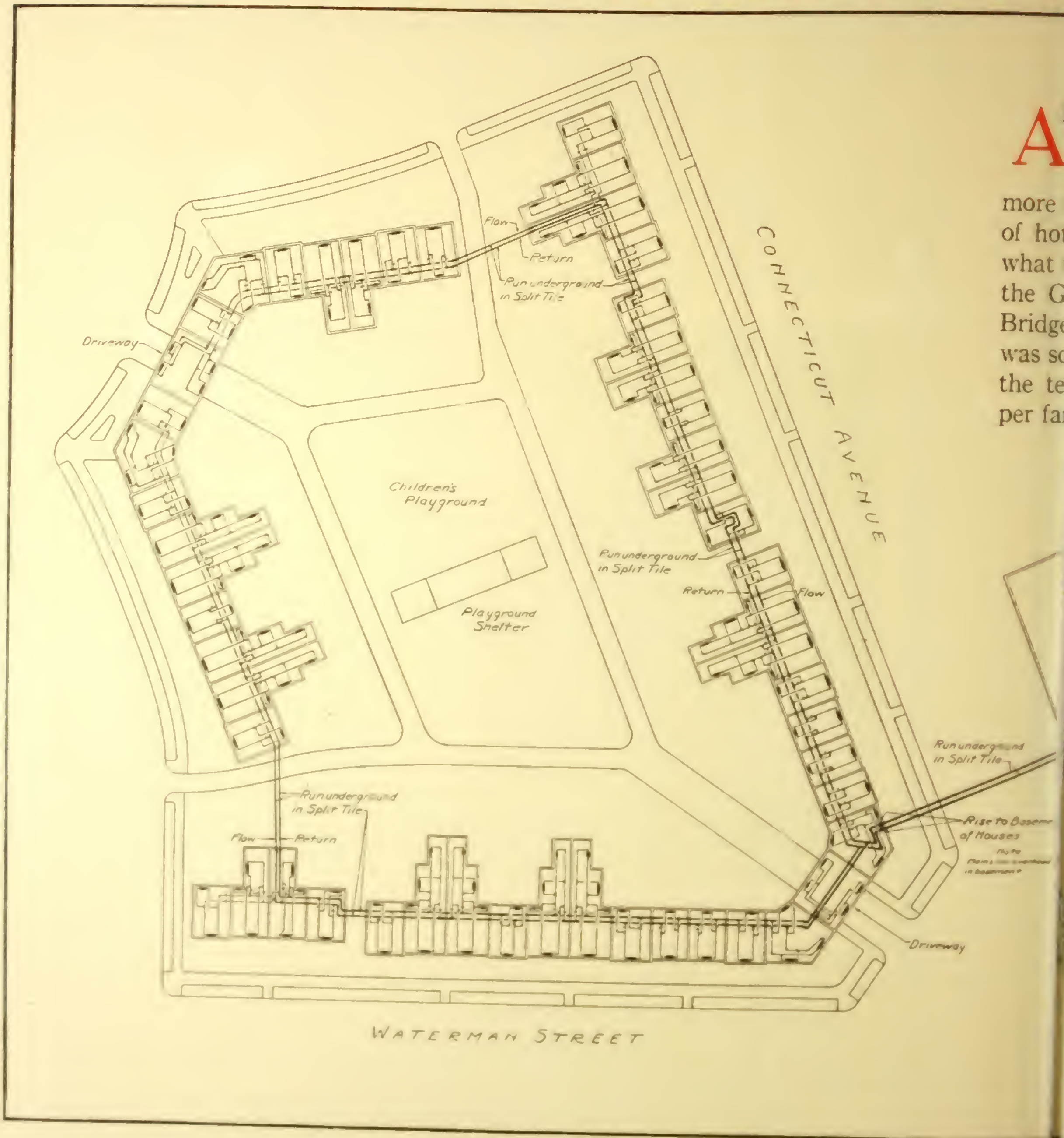
The control of room temperature with this system is absolutely in the hands of the engineer who is responsible for the running of the power and heating plant. He varies the temperature of the water in accordance with the fluctuations of outside temperature, a chart of the proper outgoing water temperature to meet outside temperatures being posted before him in the engine room. With the Grinnell System, this single regulation of the temperature of the heating medium insures the proper change in inside temperature throughout the plant.

Lathe Shop in Youngstown Pressed Steel Plant at Warren, Ohio, heated by Grinnell Hot Water System. Picture Shows Heating Coils About Door and Also at Ceiling. In Spite of Large Glass Surfaces We Guaranteed Temperature

This positive control of temperature throughout even the largest plant is made possible only through the studious calculation of pipe sizes in relation to frictional resistance and the exact figuring of radiation in relation to heat losses. The success and economy of the Grinnell Hot Water Heating System is due to careful study of these engineering factors, particularly friction loss in various sizes of pipe.

The importance of this matter is made clear by the following statement made before the American Society of Heating Engineers by the late Prof. John R. Allen, formerly of the University of Minnesota and Director of the Bureau of Research of the Society:

(Continued on page 16)



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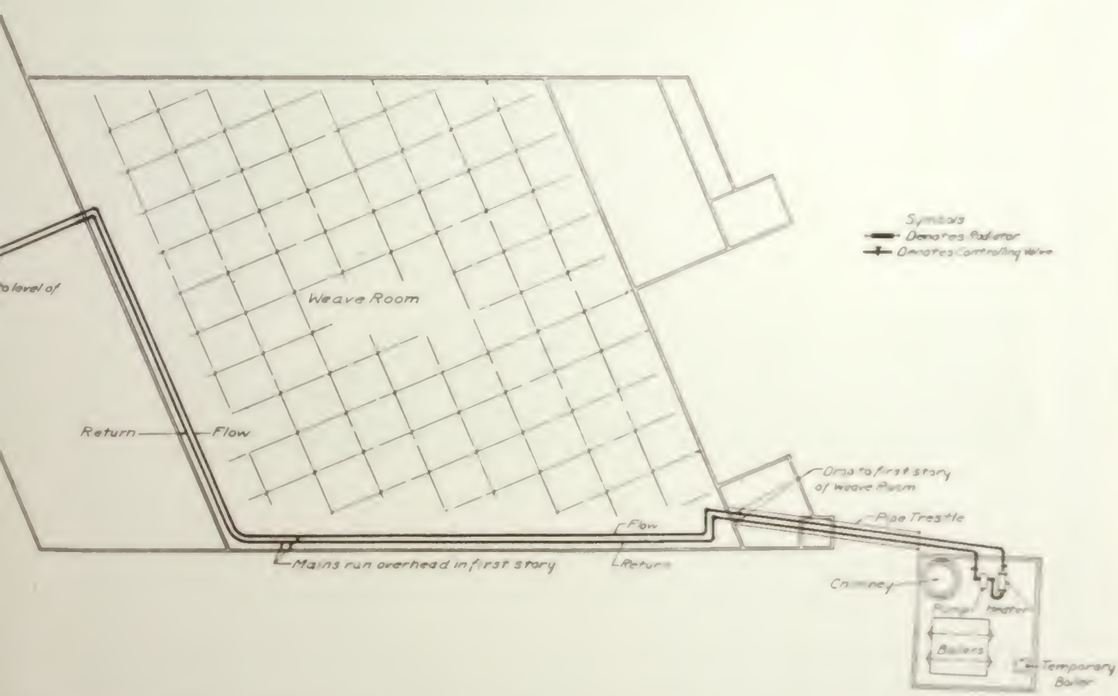
RLY engineered forced circulation hot water system is particularly suited to a group of buildings from a central station. In the first place supply and mains can be run up or down at will without the necessity for providing a xpensive and bothersome drainage system. In the second place the flexibility allows positive control by the man in charge of the heating plant no matter ide temperature changes. The drawing reproduced here shows the layout of Hot Water System in a group housing project for A. & E. Henkels, Inc., onn. In this system heat losses were calculated so exactly and the circulation nly excellent that there are no valves on individual radiators at all. During inter of 1919-20, these dwellings were kept uniformly comfortable at a cost about 10 cents a day.



"In this country we probably give less consideration to pipe sizes than in any other engineering country. The sins committed by the average contractor in the matter of pipe sizes are legion. When we get down to the economical use of pipe, there is just one way to determine the sizes and that is to determine the resistance of each piece of pipe. We design good fan piping systems for air by resistance and yet we design our steam piping sizes on a heating job by guess work and experience—these terms are sometimes synonymous.

"To take the pipe sizes out of a table and have them determined by the square feet of radiation is no basis of reason on a large job. It is quite possible that close to the boiler you can put 150 sq. ft.

Youngstown Pressed Steel Company. Note Particularly the Treatment of Heating Coils Under the Huge Expanse of Glass Surface

of radiation on a 1¼ inch riser, while at a remote point a 1¼ inch riser might only carry 60 sq. ft. A tremendous amount of pipe is wasted in the heating business by using excessive sizes. To design a system of this kind requires great accuracy, but gives economical results.

"The modern piping system in a steam heating installation always reminds me of a small pumping station I once inspected. The Board of Directors had purchased a pump with a 2-inch discharge and they instructed the engineer to run the 2-inch pipe from the pump, a distance of three-quarters of a mile. When I came to examine the pipe, I found that the pump was working against a static head of 70 lbs., and friction head of 100 lbs., and that in

place of a 2-inch pipe, they should have a 6-inch pipe when the calculations were based on friction.

Pipe Used Often Too Large

"In the heating business, however, we more often make the mistake of using pipe too large, rather than pipe too small, particularly in the smaller installations. In hot water piping with forced circulation, it is absolutely necessary to work from friction, if uniform circulation and no short circuiting is expected."

Grinnell Engineers Know Proper Design

These observations of Prof. Allen's have been known to Grinnell Engineers for years. Scores of Grinnell Systems long in operation are a practical proof of their soundness. The success of these systems is due to proper design—design based on careful engineering study of the many variables involved. The result is a system that enables your engineer to know that with zero temperature outdoors, the outgoing water should be 195 degrees; that with 30 degrees outside, the outgoing water temperature should be 175 degrees; etc. These relative temperatures of course vary with different buildings.

Professor S. Homer Woodbridge, writing in a recent issue of the Heating and Ventilating Magazine, sums up these advantages of Hot Water Heating as follows:

"A greater economy in the use of fuel for heating purposes is hardly possible than that attainable in the use of a hot water system successfully designed, installed and operated."

It is natural that we as the oldest and largest concern in the automatic sprinkler business as well as the country's oldest firm in the heating business, should have been the pioneer in this type of heating system. The basic idea of automatic sprinkler protection is to deliver at each sprinkler head a certain amount of water no matter where the head is located.

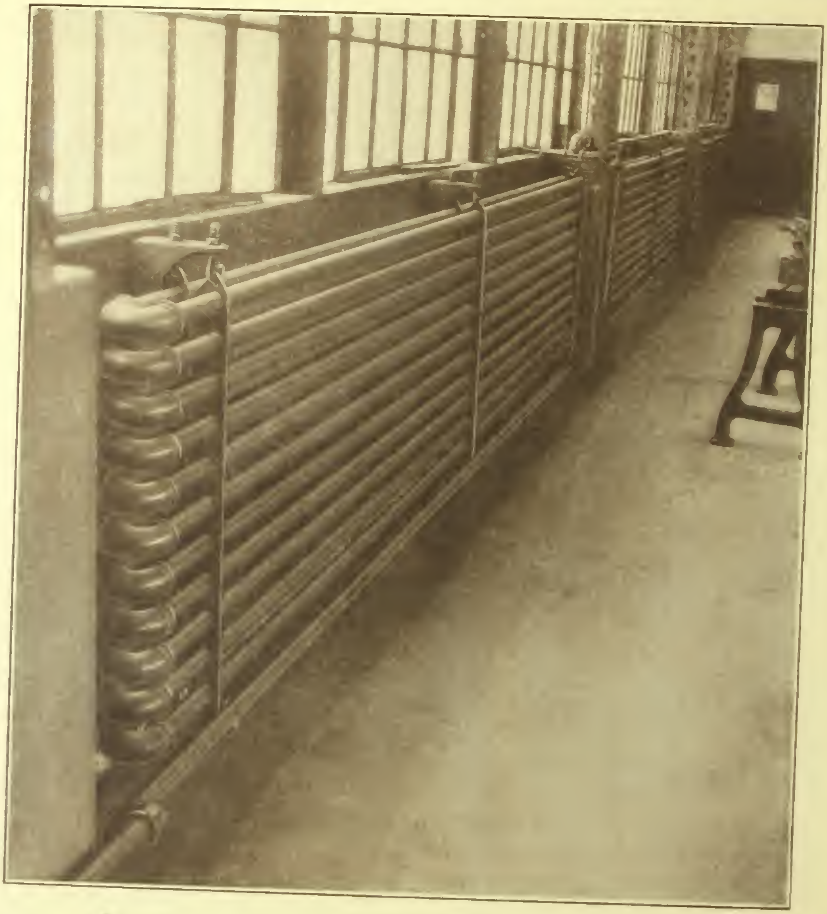
Grading Pipe Sizes By Science

In sprinkler systems, varying pressures and the possible opening of one or a dozen heads, made the grading of pipe sizes only exact enough to provide the necessarily large factor of safety. But that basic idea has in the Grinnell Hot Water Heating System been refined and perfected to an astonishing degree. Such an exact determination of pipe sizes as has been developed in this heating system is demanded in the interests of economy and satisfaction, for behind pipe sizes is the fundamental question of calculating and equalizing frictional resistance. In other words when we discard the old rule of thumb method and get down to a real study of frictional resistance figures and then carefully equalize all connections, we get small pipe sizes and a better circulating system. Small pipe sizes are thus

not so much a cause as they are a symbol—a symbol of better engineering. And in many Grinnell Hot Water Heating Systems there is a great amount of pipe as small as $^3/_8$ inch.

Means Big Fuel Savings

Elasticity in the heating medium with the consequent ease of temperature control is the engineer's way of saying, "Big savings in your fuel bills." Every minute you use heat that isn't needed



Side Wall Radiation at Lodge & Shipley Plant Showing Grinnell Adjustable Hanger for this Particular Purpose

means waste—waste that comes out of net profits. It is easy to say what a hot water system *should* save you in operating cost over a steam system. But it would be an estimate—based on theorizing. Theorizing about how many heatless days or parts of days there are in a season—theorizing about how many windows your employees will open or how carefully they will look after steam radiator valves,

etc. It is better not to make such a statement. Your common sense working on the principles we have tried to outline, will give you a better answer than our statement based on theoretical averages.

Adaptability

Adaptability is one of the factors involved in the choice of a heating system and in some plants it is an exceedingly important one. By adaptability we do not mean "ability to heat" but "fitting into the conditions existing."

View of Radiation Around a Door in Lodge & Shipley Plant, Cinn., Where Grinnell Hot Water Heating System Saved so Much in One Building it Heated Another Twice the Size for Nothing a Year

Previously we have said that the hot water system was not particularly adaptable to the small industrial plant. For the large industrial plant, however, and with known requirements, the hot water system is "adaptable" in every sense of the word. Take for instance the handling of the piping, particularly large mains. With steam systems there is always the necessity for proper drainage. This usually requires burying a part of the steam or return piping. With the hot water system both supply and return mains can be raised or lowered at will. In other words, with hot water your plant conditions determine the location of pipe, whereas with

steam there is no such adaptability and plant conditions must bow to piping necessities.

Easy To Change Levels With Hot Water System

More than this, raising or lowering hot water piping requires no complicated devices other than simple air traps for venting. With steam, whether blower system or vacuum, it is necessary to install pumps and traps, often in pits, in order to keep the steam lines drained and to return the water of condensation to the boiler room.

With a hot water system you can put your piping where you please. With a steam system, pipe may have to go down when your processes demand that it go up. But down she goes just the same! With hot water your piping fits your plant. With steam your plant must fit your piping. Think what this "adaptability" of hot water means!

ASSABET MILLS, MAYNARD, MASS.

The Hot Water System does more than conveniently conform to plant conditions as regards the piping. It is by all odds the best system for the easy utilization of exhaust steam or waste heat of any kind. The problems surrounding the running of a heating system in conjunction with the power plant are so varied as to make generalization impossible. Important economies can be effected by early consultation with expert heating engineers.

The possibilities of utilizing waste heat with the hot water system are practically limitless. This development has been held up, like many others in the heating field, by the failure of the buyers of such equipment to give adequate consideration to the question of operating expense as against first cost. Grinnell engineers are now studying this matter thoroughly and we have reason to believe that in

many plants heating will eventually be simply a by-product of other essential plant processes.

Picking Up Waste Heat

Naturally this whole subject is closely bound up with plant processes and, therefore, differs in practically every individual plant. Certain basic considerations, however, will serve to show why the hot water system is ideally suited to turn waste heat into dollars.

This Weave Room in the White Oak Cotton Mills is the Largest in the World. It is a Good Example of Grinnell Industrial Piping, having a Grinnell Steam Heating System—Grinnell Sprinkler System and American Moistening Company Humidification

In the first place, the return lines, due to forced circulation, can be run to any part of the plant where there is heat to be picked up at a profit.

In the second place, hot water due to its relatively low temperature, can pick up heat from processes where the waste heat temperature is not exceedingly high.

All Heat Utilized

In the third place, every degree of heat picked up on the return to the boilers can be utilized in actually heating the plant. This is due to the fact that hot water radiates heat whenever its temperature is higher than that of the surrounding air and does not, as does steam, require 212 degrees before it can radiate heat at the place where heat is needed.

Knowing the desired temperature of outgoing water and the actual temperature of the incoming water at the end of the return mains, your engineer "fires" only to make up the difference. And

the difference will vary in direct proportion to the waste heat that can be picked up by a scientific running of the return lines to processes where heat is now going to waste.

The System For Large Industrial Plants

This, as other features of the Grinnell Hot Water Heating System, is due in a large measure to the fact that everything possible is determined in advance by science with the consequent result that the effect of such additions to temperature as waste heat may produce, can be calculated and fully taken advantage of. That, plus its infinite adaptability, makes it truly the system which industry in its larger units must almost perforce consider not only in the interests of economy, but in the interests of comfort and reliability.

Maintenance

Maintenance Higher In Steam Systems

The simplicity of construction of the hot water system, as against the more or less complicated devices used in vacuum and blower steam systems, obviously works to decrease maintenance trouble and expense in the former system. As previously pointed out, the hot water system has no valves or any other mechanical contrivances except the main control-valve in the boiler house and simple shut-off valves on the branch lines so that, if necessary, one part of the system can be inoperative without affecting the whole equipment.

With the vacuum steam system, vacuum valves or traps must be installed at all low points or on individual radiating units. Naturally these require more or less constant supervision, cleaning and adjustment. In addition, pumps or return traps, due to change of levels, are often required at low points isolated from the boiler house, with consequent additional maintenance trouble and expense.

Keep Maintenance In Mind

With the blower system, especially on large jobs, it is necessary to have fans and blowers placed at various isolated points. And each fan unit must have its own motor or engine to drive the fan, as well as its own series of control valves for tempering coil and re-heaters. All this means more than heavy operating expense, because each of these little plants must have expert and constant attention. And that means big maintenance charges. It's something like having a separate carburetor for each cylinder of your automobile engine!

These are some of the items of heating system maintenance the manufacturer should have in mind when he is weighing the estimates of first cost.

Depreciation.

Closely identified with maintenance expense is depreciation. It has sometimes been argued that the life of a hot water heating system is less than that of a steam system on account of the pressure in the former system due to forced circulation. Of course anyone who is familiar with piping knows that the relatively low pressure in a system such as the Grinnell System is, has no effect on pipe or fittings, except in so far as it necessitates tight joints. This is largely a matter of proper threading and installation, and is something which we have no hesitancy in guaranteeing. Sprinkler equipments carrying a far greater volume of water under much heavier pressures last indefinitely. So do hot water heating systems.

Small Depreciation In Hot Water Systems

The most important element to be considered in the relative depreciation of steam and hot water systems is corrosion. We believe it is generally conceded by engineers that as far as corrosion is concerned the hot water system is far preferable to the steam system. The reason for this lies in the chemical action on iron or steel of the free oxygen carried into the lines. Cold feed water will carry in solution from 1.4 to 2.3 cubic inches of oxygen per gallon at ordinary temperature and atmospheric pressure.

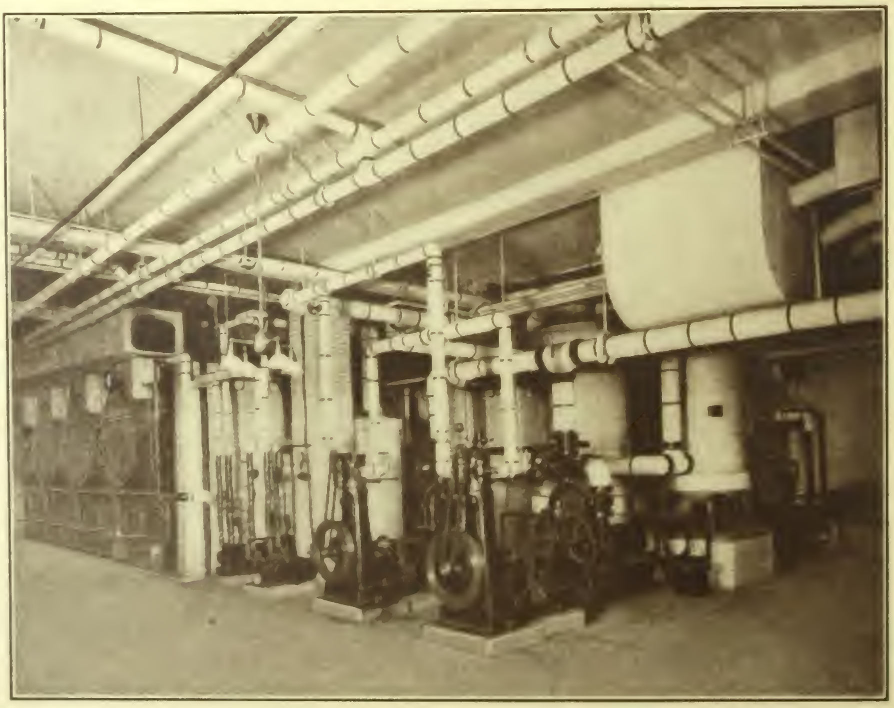
Free From Corrosion

When the temperature of this water is raised above 180 degrees Fahrenheit, the amount of oxygen carried in solution is reduced to practically nothing. With the Grinnell Hot Water System, as soon as water is turned on, it is heated to 200 degrees so that the water immediately loses its corrosive property. Since new feed water is very seldom, if ever, added to the system in any quantity, the possibility of corrosion is practically eliminated. Piping removed from a hot water system twenty-five years old has shown practically no corrosion.

In contrast to this, let us now consider what happens in a steam system. With this system considerable quantities of "make-up water" are constantly being added, due to the inevitable losses in the form of vapor or steam which pass out through vents, valves, etc. The addition of this water is constantly introducing fresh oxygen—the corrosive agent. This supply of oxygen is increased by the air being constantly drawn into the line through the vents whenever the system cools down. Generally speaking, the returns and cooler portions of the steam lines are the first to show corrosive

Why There is Corrosion in Steam Lines

Exterior and Boiler Room of Federal Building, Providence, R. I.
Heated by a Grinnell Hot Water System.



troubles, for although condensed water free from oxygen will of itself not attack iron on account of its great purity, it does absorb very readily any supply of oxygen which may become available. The oxygen which has been thrown out of solution while the system was hot, together with that taken into the system as air drawn in through the vents, is re-absorbed by this water of condensation which lies in low parts of the system or which is running back to the heater. So great does the corrosive influence of this water often become that it literally cuts its way through the metal. This is strikingly illustrated in the picture below.

Effect of Corrosion On Pipe Taken From Steam System Fifteen Years Old

In addition to the actual destruction of pipe after a certain period, more or less constant trouble is experienced in some systems, due to rust accumulating in the smaller lines of the system.

A further element of depreciation in steam systems is in the valves which are constantly being turned off and on to regulate the heat with a consequent wearing of vital parts and the necessity for their replacement.

First Cost

The first cost of a heating system should never be considered apart from the four other factors in heating costs — operating expense, adaptability, maintenance and depreciation. The *low price* system is often the *high cost* system, because heating is a continuing operation.

Heating System as an Investment

Heating may very profitably be considered as a partial payment investment in the warmth, comfort and efficiency of your employees. So considered, the purchase price of the equipment is simply the initial payment on your partial payment investment. Future payments take the shape of fuel and repair bills, proper depreciation charges and adequate interest charges on the price of the system. The average successful business man may expect (turn-over considered) to net at least 15% a year on his capital and he would be justified in selecting a higher priced system over a lower only when the saving made by the former equals or exceeds 15% on the differ-

General View of the Great Worthington Pump and Machinery Company at Harrison, N. J., Heated by a Grinnell Hot Water System

ence in the price. Such savings, of course, should take into consideration interest, maintenance and depreciation charges for the two systems. For instance, with two systems costing respectively $75,000 and $100,000 to install, the higher priced equipment should show a yearly heating cost less by at least $3750 (15% on the difference in cost) than the cheaper system. In computing such figures, 6% for steam and 2% for hot water may conservatively be used as depreciation percentages.

Our Way of Figuring

It is our firm conviction that much badly needed fuel would be conserved and a great deal of money saved if manufacturers would analyze their heating problems along the general lines we have tried to indicate in this booklet.

While it is useless to make statements as to what hot water systems will do in any given plant, it is possible to give certain data as to the relative efficiency of hot water as against steam systems. Such data is contained in the following summary of tests conducted at considerable expense by our engineers in the mills indicated. These tests, of course, do not illustrate the chief economy of hot water which, as has been shown, is its ability to quickly meet violent temperature fluctuations. It is to be particularly noted in the average figures in the last column that the average outside temperature was lower in the hot water tests and that the inside temperature was higher. Even at that, the resultant saving (H. P. required per million cubic feet) was 43%. One of the reasons for this better performance of Hot Water Systems is thus explained by Professor Woodbridge in his article previously mentioned.

"At the boiler end of heating systems, hot water has the advantage over steam because of the larger proportion of heat extracted from the combustion gas by the cooler fire surface of the water boiler."

	Whitman Mills New Bedford, Mass.	Wood Mills	Pierce Mfg. Co., New Bedford, Mass.	New Bedford Cotton Mills, New Bedford, Mass.	Pacific Mills, Lawrence, Mass.	Average
Heating System	Hot Water	Hot Water	Hot Water	Hot Water	Hot Water	Hot Water
Cu. ft. air space heated	5,993,000	12,100,000	7,000,000	5,180,000	9,300,000	7,892,724
Boiler H. P. required to heat	143.9	257.0	194.0	158.6	182.0	179.4
Sq. ft. glass equivalent	86,000			61,000		82,500
H. P. required per 1,000,000 cu. ft. air space	**24.0**	**21.2**	**31.5**	**28.7**	**17.2**	**22.6**
H. P. required per 1,000 sq. ft. of glass equivalent	1.7			1.71		
Average outside temperature	40.9°	26.0°	24°	21.8°	29.8°	28.2°
Average temperature maintained inside buildings	77.2°	72.9°	78.2°	75.3°	72.1°	75.8°

	Whitman Mills, New Bedford, Mass.	Grinnell Mills, No. 1, New Bedford, Mass.	Grinnell Mills, No. 2, New Bedford, Mass.	Quissett Mills, New Bedford, Mass.	Kilburn Mills, New Bedford, Mass.	Average
Heating Systems	Vac. Steam	Live Steam	Live Steam	Vac. Steam	Live Steam	
Cu. ft. air space heated	5,242,000	3,264,000	2,513,000	4,590,000	3,922,000	3,910,200
Boiler H. P. required to heat	172.5	180.6	121.0	152.5	139.7	153.3
Sq. ft. glass equivalent	67,000			55,000	32,000	50,000
H. P. required per 1,000,000 cu. ft. air space	**33.2**	**54.8**	**43.7**	**33.3**	**40.1**	**39.8**
H. P. required per 1,000 sq. ft. of glass equivalent	2.5			2.6	3.06	2.73
Average outside temperature	40.9°	30.6°	21.0°	27.6°	25.5°	31.9°
Average temperature maintained inside buildings	72.6°	74.1°	77.4°	68.5°	70.5°	72.6°

FOR our own part, we are always glad to co-operate in the heartiest way with architects and engineers when they are handling heating requirements. In many cases they find our actual field experience, not only in heating, but in other related lines of industrial piping, of real service in settling problems which have to do with the practical application of engineering plans. In general, architects and engineers are entirely familiar with our construction ability and know that it is the product of the largest as well as the most painstaking pipe erecting organization in the world. They know us favorably as consultant-manufacturers in all that relates to industrial piping.

Where heating is being handled direct, we have in our various branch offices complete engineering corps, competent to design and prepare working plans of any heating system, no matter what its type or magnitude. To manufacturers seeking service of this kind, we offer a unique combination of engineering, manufacturing and construction experience that has been accumulating for seventy years of successful business effort in the whole field of industrial piping.

[illegible] Press, Providence

GRINNELL GUARANTEE

PLANT owners hesitate to adopt "new" ideas in so vital an equipment as a heating system. The idea of hot water heating is new to some people only because they have not had experience with it. We ask no one to take our word for what a Grinnell Hot Water System will do. We guarantee it to do exactly what it is designed to do.